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Teaching chemistry in a local vessel: an innovation during the COVID-19 era

Ihesinachi A. Kalagbor[1] and Henry S. Amadi [2.]

[1.]Department of Chemistry, Faculty of Science Rivers state University Nkpolu-Oroworukwo P.M.B. 5080 Port Harcourt Rivers State, Nigeria.

[2.] Department of Science Laboratory Technology, Kenule Beeson Saro-Wiwa Polytechnic, P.M.B. 20 Bori Rivers State, Nigeria. *ksinachi@yahoo.com

ABSTRACT

During the pandemic, restrictions to the use of science teaching laboratories and the number of students allowed for each practical class had an impact on teaching, education and research. The quality of laboratory practicals and supervision of experiments was effected. COVID - 19 led to a negative impact on our ability to carry out laboratory experiments in the core sciences and chemistry. The global lockdown cut off the supply of laboratory apparatus and chemicals. The academic curriculum for the students taking organic chemistry required amongst other things, a particular hands-on experience in fractional distillation. To achieve this objective in the face of the pandemic, the fabrication of a fractional distillation apparatus using a local vessel (an aluminium cooking pot) and a delivery arm was employed. This innovation provided the opportunity for the demonstration of the production of ethanol from waste and discarded oranges.

KEYWORDS: Fabrication, Local vessel, Laboratory practical, Teaching innovation, Organic chemistry, Fractional distillation, Delivery arm

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INTRODUCTION

Chemistry is one of the important fields in the chemical sciences. It relates to our everyday life in the foods we eat and the materials and products around us. These are made of natural and synthetic organic compounds. The public believes that chemistry's contribution to the society is greater than its harmful effects in form of chemicals[1]. Laboratory work is an integral part of learning chemistry[2]. It provides a unique setting for teaching science[3]. The benefits of engaging students in science laboratory activities were noted by Hofstein and Lauretta[4]. Chemistry as a course has many branches one of which is organic chemistry. It touches our daily lives. Almost all the reactions within and around us involves organic compounds[5] and some of them are synthesized in the laboratory. The organic chemist synthesizes a natural product in the laboratory to make it more available. It also allows creating new substances that are identical in property to the natural ones. This has led to the application of this branch of science in food science, dyes and fabrics, the paper industry, agriculture, personal products, plastics, polymers, the car industry, petroleum, furniture, household products and science disciplines such as medicine, pharmacy and biochemistry. The application of organic chemistry in life sciences, industries and the environment helps us to solve practical problems. It has played important roles in the development of the fields of modern biology, medicine and more. The new application includes advances in the development of environmentally friendly (green) methods in the chemical industry. Disease diagnosis and treatments involve new chemically-based methods[6] such as radiology and radiotherapy. Biosynthesis of many compounds, drugs and medicinal product stem from a sequence of ~~enzymes-catalyzed~~ reactions whose precursors are simple organic substances. New reactions and products are from research work carried out in laboratories. Scientists and students understand scientific concepts better in the laboratory and it is a unique learning environment. The practical content allows the students the opportunity to see new compounds formed from the breaking and making of bonds which they have learnt in the theoretical class[7]. They also learn to carry out quantitative and qualitative analyses of these compounds thereby acquiring better skills and understanding of the processes involved in synthesis and production. It integrates and combines both minds-on and hands-on activities bringing the theory to practice. Laboratory activities have played important roles in the science and curriculum as a means of making the learning of science more relevant and motivating[8]. The future research chemist will need to put in some years of laboratory-based training, especially those who want to learn a particular technique to effectively carry out a research work. The COVID-19 pandemic era was a challenging one. Many institutions had to convert in-person lectures to virtual learning some university lecturers needed to find a way to teach their organic chemistry classes and biochemistry laboratory courses[9]. They were able to do this from a distance by being creative. Replacing traditional laboratory work with virtual labs was not quickly achievable. It is expected that there will always be a case where the chemist will have to be in the laboratory and handle the equipment as well as carry out the experiment. Teaching students in the laboratory has been a long-standing method for decades. The lockdown and restrictions during the pandemic allowed us to think outside the box, leading to the innovation of a fabricated aluminum cooking pot with a delivery arm for fractional distillation in place of the 1-liter (1000ml) round-bottomed flask.

MATERIALS AND METHODS

Materials:

Fabrication of the Distillation Vessel

An aluminum cooking pot, 24cm^2 was used. An angle steel pipe was soldered to the cover to serve as the delivery arm. The Liebig condenser was connected to carry the vapor from the pot, condense it and allow it to drip into the collection beaker. The condenser is a straight glass surrounded by a water jacket[10]. A tiny hole was made on the cover near the delivery arm for the insertion of the mercury-in-glass thermometer. This is the local distillation vessel.

Plate 1: The Aluminum vessel after fabrication

Preparation of Sample for Distillation

The application of this simple apparatus was in the laboratory production of ethanol from discarded oranges. These oranges were considered unfit for consumption by the sellers and they were collected and taken to the laboratory where they were selected, washed and the skin

peeled using clean knives. About 4kg of the peeled (waste) oranges was

Plate 2: Peeling and shredding of waste oranges

weighed out and put in the pot, 20g of yeast was poured into the content of the pot and mixed thoroughly. The pot was tightly covered and allowed to stand for 72 hours to allow for a complete fermentation.

The Distillation Process

After fermentation, a Liebig condenser was connected to the delivery arm with the thermometer inserted. The pot was then placed on a Bunsen burner and heated (Plate 3-4).

At 77-79^{o}C, ethanol was collected from the Liebig condenser into a clean 500ml beaker (Plate 5). The ethanol produced was transferred into a storage bottle and labelled accordingly.

Plate 3: Connecting the Liebig condenser and a thermometer

Plate 4: Fractional distillation in progress

Plate 5: Collecting the condensed liquid (Ethanol) in a beaker

DISCUSSION

Eighty (80) students were involved in ten groups of 8 students per set-up. The laboratory practical was carried out in four batches. In each vessel, 4kg of peeled waste orange was put. The volume of ethanol produced in each group ranged from 170 – 195 ml.

It was an avenue to activate the students' zeal to partake meaningfully after a long period of lockdown and delays in the delivery of laboratory equipment, apparatus, glassware and reagents. In this innovation, a familiar tool (the cooking pot) was used to make the chemistry practical more interesting, more relevant and sustainable. The use of waste and discarded oranges to produce ethanol was a practical demonstration of converting waste to wealth.

CONCLUSION

The COVID-19 pandemic era was a challenging one. Many institutions had to convert laboratory practical work to virtual learning. To achieve continuity in teaching chemistry in the laboratory after the lockdown, there was a need for us to be creative. This innovation not only created an alternative vessel for the 1000ml round bottom flask glassware but also gave the students the opportunity of knowing that they can also be creative.

Students can learn laboratory techniques remotely but it cannot replace hands-on practical experience which is a key component to a chemistry degree. The aim of teaching practical chemistry by demonstrating that fractional distillation can be carried out using a fabricated local vessel was achieved. The students' enthusiasm for more of this practical demonstration was high.

HAZARDS AND SAFETY PRECAUTIONS

The demonstration is a simple fractional distillation for the production of ethanol from waste orange fruits. No chemicals are involved. The flame from the Bunsen burner was well regulated to avoid excess heat and boiling over of the mixture in the local vessel. The beaker receiving the produced ethanol was kept at a safe distance from the Bunsen burner.

AUTHOR INFORMATION

Corresponding Author

Ihesinachi A. Kalagbor – Department of Chemistry, Faculty of Science. Rivers State University. Orcid 0000-0001-7696-3346 email: Ihesinachi.kalagbor@ust.edu.ng

Author

Henry S. Amadi – Department of Science Laboratory Technology, School of Applied Sciences Kenule Beeson Saro-Wiwa Polytechnic, Bori. email: amadihenry115@gmail.com

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